

SYMPOSIUM X
Frontiers of Materials Research

Authoritative Reviews for Nonspecialist

March 29 - 31, 2005

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* Invited paper

SESSION X1:
Tuesday Afternoon, March 29, 2005
Room 2010/2012 (Moscone West)

12:05 PM *X1.1

The Magic World of Flavors and Fragrances. Cyril Mahaim,
Global Industrialization, Firmenich SA, Geneva, Switzerland.

A short introduction to olfaction and taste is given. An overview of the industry is presented, with an emphasis on applications. Some of the most recent materials used in Fragrances and Flavors are described, molecules or carriers for delivery systems. In conclusion, the challenges awaiting this industry in the 21st Century are discussed. "Scratch and sniff" samples will be provided.

12:45 PM *X1.2

Science and Sculpture: The Fabulous Discoveries of 8 years of Collaboration. Rolf Gotthardt¹ and Etienne Krahenbuhl¹; ¹*École Polytechnique Fédéral de Lausanne, Institute of Physics of Complex Matter, Lausanne, Switzerland; ²Romainmotier, Switzerland.

Shape memory alloys (SMAs) were discovered more than 50 years ago. Due to their shape memory and super-elastic characteristics they are interesting for both fundamental physics and industrial applications. In recent years SMAs have become more affordable, particularly Ni-Ti and Cu-Zn-Al alloys. Given that they are widely available and uncannily lifelike, it is very surprising that they haven't been used more often in art. Several reasons suggest themselves - perhaps artists don't understand the phenomenon well enough, or the materials don't behave the way they are supposed to, and after a few failures the artists abandon them. We draw upon our 8 years of scientific and artistic collaboration to shed some light on this question, describing how we came together, some of the challenges we encountered and some of the traps we were able to avoid. We conclude that our successful use of SMAs for the creation of new sculptures was possible due to the steady, permanent contact we maintained throughout our collaboration. We find that in the process of creating a sculpture, doors always open onto new ideas and technical possibilities. In this manner our collaboration continues its uncharted voyage, and we eagerly anticipate the next challenge we will encounter in this journey to discovery.

SESSION X2:
Wednesday Afternoon, March 30, 2005
Room 2010/2012 (Moscone West)

12:05 PM *X2.1

Nanoscience at the National Labs. Julia Phillips, Sandia National Labs, Albuquerque, New Mexico.

The National Nanotechnology Initiative (NNI) is an initiative that involves the government agencies that support science research in the United States. The largest manifestation of NNI in the Department of Energy is the establishment of five nanoscience research centers located at DOE national laboratories around the country. These are the Center for Nanophase Materials Science at Oak Ridge National Laboratory, the Molecular Foundry at Lawrence Berkeley National Laboratory, the Center for Integrated NanoTechnologies at Sandia and Los Alamos National Laboratories, the Center for Functional Nanomaterials at Brookhaven National Laboratory, and the Center for Nanoscale Materials at Argonne National Laboratory. The Centers are currently under construction and will begin full operation over the next year or so. Each Center is expected to host a large user community, with users selected through a peer review of proposals to use the facilities. I will discuss the capabilities of these Centers and the different strengths that each brings to the nanoscience community. I will also highlight a few of the exciting science results already emerging from the Centers.

12:45 PM *X2.2

Biom mineralization: Fascinating Processes and Materials Developed After Millions of Years of "On-Site Testing". Steve Weiner and Lia Addadi; Structural Biology, Weizmann Institute, Rehovot, Israel.

Organisms have been using minerals for more than 3 billion years. They are able to produce more than 60 different mineral types, in an almost infinite array of structural motifs. The mineralized tissues fulfill many different functions. Biology has evolved the know-how to control almost every aspect of the mineralization process. Furthermore, many of these materials contain commonplace minerals with poor mechanical properties. Yet organisms have often found ingenious solutions to overcoming these problems. Understanding how this is achieved is of much interest in its own right. This in turn often reveals surprising solutions to difficult problems; some of which may

be useful in materials science. The sea urchin produces huge single crystals of calcite with smooth and curved surfaces. Its biogenic calcite cleaves with a conchoidal glassy fracture, despite the fact that non-biogenic calcite has well defined cleavage planes. Many of these enigmatic properties can now be attributed to the unique formation processes used by sea urchins and other marine organisms, namely the initial deposition of a transient amorphous calcium carbonate mineral phase that subsequently crystallizes into a single crystal. The occlusion of macromolecules along specific crystal planes oblique to the cleavage planes, is responsible for the glassy cleavage properties. The self-sharpening sea urchin teeth are also marvels of structural design. They incorporate fibrous elements that have progressively smaller dimensions and continuously varying inclusions to produce grinding tips of great hardness and durability. Some mollusks also produce teeth continuously, using a conveyor belt-like system. The chiton tooth has an outer layer composed of magnetite that forms via an amorphous precursor phase, ferrihydrite. The inner layer is composed of carbonated hydroxyapatite that forms via an amorphous calcium phosphate precursor phase. The two layers are separated by a thin layer of the iron oxide mineral, lepidocrocite, that probably acts as a gasket allowing the two very different materials to work together. Bones and teeth of vertebrates are certainly the most thoroughly investigated mineralized biological materials because of their enormous medical importance. They have hierarchically ordered and graded structures, finely tuned to fulfill essential mechanical and other functions. Despite the importance of bones and teeth, major gaps in our understanding of their complex structures exist, and very little is known about their structure-mechanical function relations. The biomineralization world is replete with beautiful objects that fulfill diverse functions, many of which pose fascinating unsolved problems that are waiting for the attention of materials scientists. Supported by grant DE006954 from the NIDCR to SW.

SESSION X3:
Thursday Afternoon, March 31, 2005
Room 2010/2012 (Moscone West)

12:05 PM *X3.1

Nano-Silicon à la Carte. Ulrich Goesele, Experimental Department II, Max Planck Institute of Microstructure Physics, Halle, Germany.

Silicon is the mainstay of microelectronics and of MEMS. Over time we have learned to control silicon from 300 mm diameter single crystals to nanocrystals and nanowires with diameters in the few nanometer range. The talk will deal with some of the more unusual top-down, bottom-up and other methods to sculpture silicon from the micrometer to nanometer range for photonics, microelectronics, micropumps, templates or just for fun.

12:45 PM *X3.2

Rich Phases and Gigantic Response of Correlated Electrons. Yoshinori Tokura, ¹University of Tokyo, Tokyo, Japan; ²ERATO Spin Superstructure Project, JST, Tokyo, Japan; ³Correlated Electron Research Center (CERC), AIST, Tokyo, Japan.

Transition-metal oxides offer an intriguing playground to find amazing electronic property/functionality, such as high-temperature superconductivity in copper-oxides and colossal magnetoresistance in manganese-oxides. In those materials, a vast number of electrons, comparable to the number of the constituent atoms, are strongly interacting with each other and tend to lose their mobility. Such a particle nature of electrons, contrary to the cases of conventional metals and semiconductors, can activate the internal degrees of freedom of an electron - charge, spin, and orbital (electron's probability-density distribution). These correlated electrons, when placed on the specific topological atomic lattice, may form the rich and complex phases or the self-organized structures. Those are, for example, charge-spin stripes, charge-orbital ordered states, and liquid-crystal like states with anisotropic charge-spin-orbital correlations. Here I would present some of ample examples of the correlated-electron's ordering patterns and how dramatically they can respond to external stimuli (inputs), say to electric/magnetic fields, light, and pressure. In particular, the response of correlated electrons can be huge and fast in the vicinity of the boundary of the competing electronic phases. Importantly, reflecting the regained particle-nature of electrons, the gigantic response can be robust to down-sizing of the material form to nano-scale and hence be promising for future applications.